

**From:** Aaron Nissen  
**To:** Jerry Hintze  
**Date:** 1/9/03 10:56AM  
**Subject:** REBUTTAL: ...Comments from Alstrom

Jerry-

It really would be helpful if you read the comments sent back to Phong/ Alstrom/ Maintenance on the issues of slow speed balancing, so when we get together we're talking about the same things. Obviously, this goes beyond just the rotor balancing and touches on Turbine QA/QC issues.

**IGS IP Turbine- slow speed balancing issues, turbine alignment and startup vibration issues:**

REBUTTAL to Alstrom comments (via Phong Do):

Please see the note below regarding balancing & run out from Alan Homes, Astom Head of Engineering. "My approach to low speed balancing".....

1 "If a shaft line is running with acceptable levels of vibration, do nothing".....

HELLO, THAT IS THE PROBLEM. WE HAVE HIGH VIBRATION GOING INTO THE OUTAGE!!!!!! WE HAVE HAD HISTORICAL VIBRATION PROBLEMS ON STARTUP. THESE WERE THE SAME ISSUES WE WERE FACED WITH GOING INTO THE IGS UNIT 2. THESE WERE NOT ADEQUATELY ADDRESSED AND RESOLVED DURING UNIT 2 OUTAGE, SO THE QUESTION IS WHAT ARE WE GOING TO DO TO ADDRESS THESE SAME ISSUES GOING INTO THE UNIT 1 OUTAGE. IF WE USE THE SAME APPROACH, WE WILL HAVE THE SAME RESULT (IE- PLACING BALANCE SHOTS IN THE HP AND IP TURBINES ON STARTUP).

PLEASE REFERENCE VIBRATION NUMBERS AND BEARING TEMPERATURES GIVEN OUT IN THE UNIT 2 OUTAGE MEETING, U2 TURBINE AREA OUTAGE MEETING AND THE PDM MEETING, AND REPEATED BELOW (with updated numbers).

IGS UNIT 1 12/16/02 10:20am

GE BN x/y BTemp  
 T1 1.14 mils 0.93 mils 187 F

1.75  
**T2 2.24 3.43 161**  
 4.40

**T3 3.44 3.90 204**  
 2.02

**T4 2.20 3.22 200**  
 2.49

**T5 0.55 2.68 189**  
 3.73

T6 1.72 1.57 179  
 1.57

T7 0.32 1.74 193  
 0.76

**T8 2.59 2.24 181**  
 1.59

T9 0.36 0.85 184  
 0.55

T10 1.74 1.65 179  
 0.82

T11 1.20 1.15 176  
 0.99

T12 2.14 2.10 172  
 0.94

T13    1.27    1.67    150  
              0.90

NOTES: Shaft riders for T5, T7 and T9 do not appear to be reading accurately, even though they have been checked out by I&C.

Additionally there are other problems associated with high vibration during turbine operation. The vibration on U1 T1 and T3 (as well as U2 T3 and T4) bearings is very load sensitive, as well as having thermal sensitivity to changes or differentials in main steam and hot reheat temperature.

1..... "Slow speed balancing simply because the rotor is out and it seems like a good idea, usually is not."

We are not doing the IP Rotor slow speed balance for fun, we are doing preventive maintenance. At issue is the high operating vibration and mid-span runout. Balancing the mid-span (offsetting the high spot), helps reduce the rate of future IP rotor creep.

#### ANALYSIS FROM CURRENT OPERATING LEVELS ON UNIT 1:

HP TURBINE- The high vibration needs to be addressed, obviously we are getting a new HP rotor, but alignment needs to be addressed as well as bearing loading. T2 bearing is 20F below average which suggests it is not loaded enough.

IP TURBINE- High vibration needs to be addressed. It appears one would certainly want to check the mid-span runout (GEK72270A) and perform a balance on this rotor to eliminate mid-span runout as a cause. T3 and T4 bearings are 20F above average which suggests this bearing is heavily loaded.

The key difference is the bearing temperature differential across the A coupling (from T2 to T3 bearings). This differential is 40F, indicating the loading is being taken up primarily by T3 bearing. Obviously, the bearing elevations (thermal growth predictions) across this coupling is not correct. We have similar problems on Unit 2, but differential bearing temp not to this severity.

2 "Never, never, never remove the factory fitted (high speed balance) weights as a matter of course. I cannot understand why anyone would even think of doing this, but my experience in North America indicates that it is almost standard practice. It completely negates the original high speed balance. (This is not likely to have been a major factor in your IP rotor problem because the rotor was bent and had a large out of balance that would swamp the factory high speed balance)."

We do not, as a matter of course, remove the original factory installed weights. Again our major objective on the low speed balance is addressing the mid-span runout. IP rotor bow is a known concern with this style GE large double flow IP rotor. Another issue was the foreign body damage caused to the rotor and repairs attempted to the blading, as a result of the failure of the intercept valve strainers. Responsibly addressing this potential source of vibration and slow speed balancing the IP rotor, eliminates this as a cause for operational vibration.

3 "Remove any weights that have been fitted for in-situ balance correction. They may be correcting an out of balance on an adjacent rotor. ie if you ever slow speed balance the new HP rotor fitted to unit 2, remove the weights added to the front end to correct the balance problem due to the IP, before balancing."

This is a very KEY POINT and one of our objectives. When we come out of the outage the rotors are balanced (HP turbine- high speed shop balanced, IP turbine- slow speed balanced, LP A B C turbines were also slow speed balanced on last outage, again primarily to address midspan runout, therefore high vibration should not be attributable to rotor "balance".

When we come out of an outage and experience high vibration, we do what we can to reduce operating vibration levels by "balancing" the turbine. This is an oxymoron because we are really unbalancing the rotors to address the other issues causing the vibration. These issues include (and I would like to address some of these shortly): rotor alignment, bearing elevations for thermal offsets, bearing loading, coupling fitups and rim and face runouts, coupling spacer fitups and runout, hydraulic coupling bolts, oil deflector installation, and control rotor balance and attachment bolt pattern. Therefore, the turbine rotors and couplings accumulate field installed (un)balance weights which are not due to rotor imbalance, but to get the units with acceptable operational vibration levels.

At some point, these weights have to be cleaned up and removed plus the original issues need to be addressed to eliminate the cause of the vibration in the first place. That window of time is during the HP-IP Turbine Overhaul. In addition to the rotor balancing, we cleanup the other weights that effectively can create more problems, if the issues creating the problems aren't effectively resolved.

#### CLARIFICATION OR OBJECTION TO ALSTOM'S COMMENT..... **"to correct the balance problem due to the IP"**

We agree with the statement that field balance shots need to be removed to effectively balance a rotor, which is what we are doing. But the reason the field balance shots were placed on the Unit 2 Alstrom HP Turbine was NOT due to slow speed balancing of the IP Turbine. I challenge that the cause is due to bearing and coupling misalignment issues. This is mainly noted from the fact that there was a major change in vibration coming through the critical speeds 1800 to 3100 rpm (Operations could not roll past 3100 rpm without tripping the turbine due to high vibration). The IP Turbine's critical speed is around 2000 rpm. The low speed balance on the IP will get it through the first critical, that critical does not change regardless of other problems. However, the low speed balance has little impact on that occurs above critical speed. I suggest we evaluate taking another step beyond what was done on Unit 2 to address and resolve coupling and spacer face and rim runouts which may be imposing an inherent crank in the shaft.

Besides Unit 1 (the primary discussion here) explain the Unit 2 startup sequence.....  
plus list current vibration numbers and how we plan to address issues during Unit 2 Outage.....

4 " Review the condition of the rotor (straightness) and any work carried out eg re-blading and make a judgement as to where any balance error might be occurring. Add or remove weights in planes close to the likely source of the out of balance."

I assume Alstrom is referring to IGS Unit 2 in this text, although we would like to see the entire text of the email to figure out what they are referring to, doesn't make sense to me. This comment appears to be from someone without practical field vibration experience. I do not know Alstrom's level of expertise in vibration analysis and field balancing, but based upon the discussions which occurred during startup of unit 2 they have NONE. We sent them detailed startup information, all vibration data collections, analysis and recommendation, plus the results. Not once, did I get any proactive feedback or direction as to "how to proceed". Comments, after the fact, were basically we shouldn't have slow speed balanced the IP rotor plus we were given horror stories from other stations they have heard about. We did not get any details from the horror stories (such as what other things were done) or names of those directly involved, just rumors. My understanding is that Alstrom does not have a turbine field balancing team or expertise. However, Alstrom's approach to turbine overhaul maintenance appears to be "precision maintenance" or getting the readings as close to zero as possible (very low acceptable tolerances). I guess if you put the turbine back together that well... you won't need a vibration field balance group to start with.

5 "As I remember from conversations with Barry Ingle, the IP rotor had a significant bend and the front coupling OD and face were trued up because they were running out of true. However you did not true up the coupling OD and face at the rear of the rotor which were likely to be running out by the same amount because the rotor bend was in the centre. In my opinion, not trueing up the rear coupling is likely to be a

major contributor to your balance problem. The IP rotor was slow speed balanced running on its journals. When the rear of the IP rotor is coupled to the LP rotor, the rabbit fit ensures that the IP coupling runs true to the LP coupling which means that the journals are not running true to each other because there is a known runout between the IP rear journal and coupling. Rugby rules require concentricity better than 0.0008" TIR journal/journal but allow 0.0012" TIR maximum coupling/coupling because it is recognised that journal/journal is most important for balance (the individual rotors are balanced supported on their journals not on their couplings). The face error on the IP rear coupling will cause the IP rotor to bend slightly when it is bolted to the LP rotor so it is running in a different bend (and balance) condition to when it was slow speed balanced. This is why we require coupling face errors to be less than 0.0005" TIR on ex service rotors (less than 0.00025" TIR on new rotors )."

I do not claim to be an expert in the field of Turbine Maintenance, however, I would like to become more involved with the decisions being made since the Results Group seems to always holding the bag during unit startup, especially when the turbine won't rollup. Obviously, we feel the outcome of any turbine overhaul should be a smooth (vibration levels well below 2.0 mils) operating machine. Precision maintenance (shooting for zero rather than just better than barely acceptable tolerances) is tough to put a dollar figure on and always involves time to achieve. However, my recollection is that we hire two technical directors from consulting firms with OEM turbine experience (such as GE or MDA), have four Alston technical directors and supervisors (two per shift), plus two IPSC QA engineers who are all suppose to help provide the expertise we need to achieve our goals. During this last overhaul, it became obvious there was a major perspective difference on which approach to take on alignments.

From the Results/Vibration Group perspective, it is very difficult to field balance out high vibration caused by bearing and coupling misalignment, which is what we routinely experience. In other words, we typically get from 20 to 80% response to how the balance shot should have reacted. This indicates that the cause is not rotor unbalance. The rotor has to be balanced running on its journals, but the mating surfaces (coupling ends) have to be trued. If the vibration was caused by IP turbine unbalance (caused by poor Outage mid-span balancing) it would be a very straight forward approach to re-field balance to correct the problem. The turbine will provide 100% direct response to the balance weights. Problems we encounter are complicated even more when you address high vibration in one area, only get a marginal response from a field balance shot, which creates high vibration in a totally new area (because we are not addressing the root cause). We are then in a game of "chasing your tail".

Phong, you have brought up several horror stories from Alstrom that they refer to as why not to slow speed balance the IP turbine. Example is the most recent story of an outage in New Brunswick where an IP rotor slow- speed balance had gone bad which has caused the unit an extended one week outage startup and over 8 pounds of weights added and the unit still has not had an acceptable startup due to high vibration. I would really love to talk to the vibration engineer working that job (because he'll probably be out of a job soon because of pressure from Management and finger-pointing from Alstrom and Outage Maintenance). A true rotor unbalance issue can be effectively resolved by field balancing (in less than a week and less than 8 pounds of weights). The reality is that the engineer was dealt a hand in which he probably had no input into the Outage Maintenance issues on turbine alignment.

There are certain situations where you can not field balance out high vibration. As an example, if there is significant bearing or coupling misalignment, a field balance shot will not correct that problem. The very best we can hope for is a marginal positive response that will keep vibration below 4.0 mils until the next opportunity (outage). We still need to go back in, identify and resolve the original CAUSE of the vibration. Due to existing high vibration issues on both Unit 1 and Unit 2, we had better have a game plan before the outage on how we are going to address and resolve these issues. These causes may include some of the following items:

rotor alignment

bearing and coupling misalignment

Unit 1 and Unit 2 both are load and thermal sensitive (to main steam and hot reheat temps) which are good indications of misalignment issues.

bearing elevations and thermal offsets (hot to cold alignment offsets)

A key aspect to alignment is where to set the bearing elevations cold, so in the hot condition the rotors are running at centerline. Do we really know how much thermal growth there is? The other issue is where are the shells growing to then they heat up?

bearing loading

How much do we utilize the bearing metal temperatures in evaluating bearing loading and judgements to where bearing elevations ought to be moved?

coupling fitups and rim and face runouts

coupling spacer fitups and runout

Getting this spacer concentric to the coupling rims are critical. This translates essentially into coupling imbalance and fitup here needs to be "nuts on".

hydraulic coupling bolts

oil deflector installation

control rotor balance and attachment bolt pattern

The control rotor (with the wrong bolt pattern) gets attached to the Alstrom rotor with out any provisions for balance checks.

diaphragm alignment

collector ring grinding

#### RECOMMENDATIONS:

1) Conduct a slow speed balance on U1 IP turbine during the Major Outage, to balance out mid-span runout and clean up old field (un)balance shots placed to lower vibration on previous startups. Obviously these two go hand-in-hand, the only weights that should be on the rotor and coupling are there for a "true balanced" rotor (this includes leaving the original high speed balance weights installed). We need to remove the bandaides that were placed to aide in reducing vibration from previous start-ups. This is going on the assumption that the comments made during the Maintenance Overhaul that the high vibration issues that exist are being addressed and corrected. If we fall back on the attitude that "it was okay before we came down", then it is probably counter-productive to slow speed balance.

2) Get the primary turbine technical director (TD), on-site PRIOR to the U1 and U2 Outages to discuss vibration and bearing temperature issues. Additionally, we need to review the outcome of the last turbine outage (note- need turbine QA/QC manual accessible so others can reference this material). Include the Results/ Vibration Group in on the conversations to give their perspective, as well as Operations, Maintenance and Engineering. Put together a gameplan on how best to address these issues (ie- what additional turbine items need to be addressed and opened up, beyond the upcoming overhaul workscope).

3) The IP turbine rotor needs to be trued up with respect to the journal bearing location in a coupled condition. It is very difficult taking accurate reading in the turbine due to blocking the tilt pad bearings. I think it was best achieved by Continental in their lathe/ milling machine, plus they then have the ability to correct out of spec (tolerance) coupling rim and face readings. Additionally, they can take accurate mid-span runout readings. This is not a normal function for us, but was setup special to verify new HP to IP fitup. However, it should be considered for use prior to each major turbine overhaul.

4) Contract a specialist to conduct another thermal growth study on the bearings and turbine shells (to be

conducted through the beginning of the outage) to determine actual thermal growth between hot and cold positions. The original GE thermal alignment settings don't appear to be accurate. We have attempted to do a similar study in the past (conducted by Mark Pixton). Results were heavily questioned, and to my knowledge, never implemented.

5) It would be nice to have some type of formal or informal meetings to discuss and buyoff with the Vibration Group during the turbine maintenance outages when changes effecting vibration (which include all of the fore-mentioned items) are discussed and made. Most of these discussions will most probably come around to the focus on the time and manpower required to fix or correct these issues versus the potential operational outcome the turbine will have on vibration, but these issues need to be brought up.

6) It would also be nice to have some advanced Turbine Maintenance Training to review and discuss the issues effecting turbine balance and vibration. Hopefully this discussion here helps make this happen!! I think unawareness and education are some of the biggest problems.

7) Complete the Capital Project to upgrade the Bentley- Nevada monitoring system. The vibration proximity probes need to be relocated into the bearing caps due to probe resonance problems.

I DO NOT WANT TO BE FACED WITH THE SAME SITUATION ON STARTUP BRINGING UNIT 1 TURBINE BACK ON-LINE. I CAN VIVIDLY REMEMBER DISCUSSIONS WITH MANAGEMENT ON HOW THIS ISSUE WON'T BE TOLERATED IN THE FUTURE, ESPECIALLY BASED ON ASSURANCES FROM OTHERS, PRIOR TO STARTUP, THAT IT WON'T HAPPEN IN THE FIRST PLACE. WE NEED TO ADDRESS AND RESOLVE THESE ISSUES BEFORE AND DURING THE OUTAGE, NOT FINGER-POINTING AFTER THE FACT.

CC: James Nelson